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U.S. Naval Observatory
Press Release

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Unusual Binary Star resolved with Unusual Optical "Telescope"

A team of astronomers from the U.S. Naval Observatory (USNO), Naval Research Laboratory (NRL) and the European Southern Observatory (ESO) have successfully used the ultra high-resolution capability of the Navy Prototype Optical Interferometer (NPOI) to track the orbit of a binary star invisible to other ground- and space-based optical telescopes.

These findings are being presented at the American Astronomical Society's 205th meeting in San Diego, California by Dr. Robert Zavala from the Flagstaff Station of the U.S Naval Observatory. Dr. Zavala is part of a team checking a list of stars for a future planet-finding satellite mission. This work also has important implications for precisely determining the properties of stars required by current computer models and the search for extrasolar planets.

Using a technique called interferometry, in which the light from several small mirrors is combined to act like a much larger single mirror, the NPOI employs an array of up to six 50-cm (20-inch) mirrors to act like a single telescope with an "effective aperture" almost 100 meters (330 feet) in diameter. Since the ability to resolve objects of very small angular size and/or separation depends on the effective aperture of an optical system, NPOI can "see" details of stars up to ten times "sharper" than the largest current single mirror telescopes.

The most recent observations were a by-product of a project to survey potential target stars of NASA's proposed Terrestrial Planet Finder (TPF) satellite. TPF will be designed to detect earth-sized planets around nearby stars.

Phi Herculis, the star studied by the astronomers, is a chemically peculiar (CP) star known as a Mercury-Manganese (HgMn) star. HgMn stars have extremely large amounts of these elements (by a factor of 100 to several thousand times) in their atmospheres compared to the Sun. Only the hotter stars in the galaxy are CP stars, and up to 20% or more of hot stars may show these chemical peculiarities.

Phi Herculis appears as a single star to even the largest optical telescopes, but periodic Doppler shifts of the light in the spectrum of this star have shown it to be a binary system. Using the NPOI the astronomers were able to separate the components of the binary system and accurately track their motions over several years. This has resulted in a precise determination of the orbit and the brightness of the previously unseen secondary star. The two stars must have formed from the same cloud of gas, and thus both stars should have the same chemical composition. So far the chemical makeup of the fainter star is not known, but this system now provides a laboratory for testing ideas about how the chemical mix in the brighter star might have become so extreme.

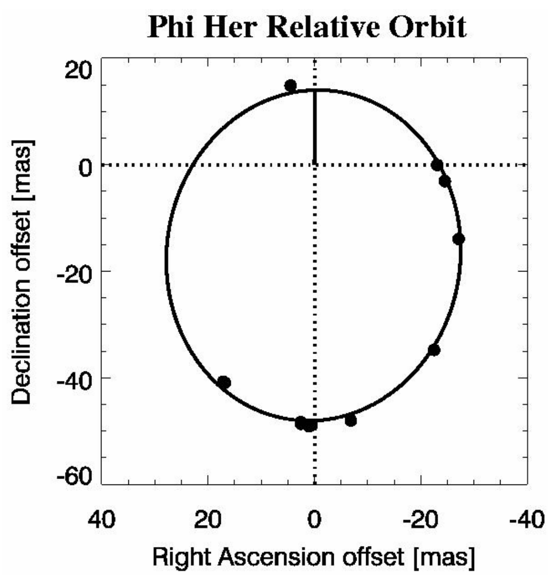
To make the observations with the NPOI requires a high degree of stability and accuracy. The positions of the mirrors need to be known to accuracies of less than a wavelength of visible light. The mirrors must track a star as it moves across the sky during the night, and send the light they collect over a distance of 100 meters or more through a system of pipes maintained in a strong vacuum. The vacuum is required to remove the effects of air on light of different wavelengths.

The light from the individual mirrors is combined in a special-purpose optics lab. This room is climate-controlled so that expansion or contraction of materials from temperature changes as well as optical effects of air are minimized. The temperature is maintained to a level of plus or minus a half degree Fahrenheit. The same changing atmosphere that causes stars to twinkle makes combining light in an interferometer difficult, so that combined light from the various mirror combinations is collected every 0.002 seconds. This rapid time sampling requires a high degree of computer automation to move mirrors, record data, and control the multitude of sub-systems.

These observations showcase the ability of the NPOI to make extremely precise measurements of the properties of stars. This is needed as computing power has enabled theoreticians to compute in great details the models of the interiors of stars and how stars evolve. Observations need to keep pace with these advanced computational methods.

The masses of stars need to be measured to the level of 1%, and that can only be done with interferometers. Although these results focus on a class of stars with peculiar chemical makeup, these same results applied to a wide variety of stars can provide the results needed to rigorously test current theories.

The same high precision measurements used to determine the orbit of this binary star can be used to search for planets. The NPOI cannot directly detect the light from an extrasolar planet, but it can detect the gravitational tug of the planet on the host star. As the planet moves in its orbit the star it belongs to will "wobble" across the sky due to the gravitational tug of the planet. The NPOI is also capable of making the precise measurements of the positions nearby of stars in the sky to enable this wobble to be detected.



Above: Relative orbital diagram of the two components of Phi Herculis.

Left: NPOI synthesized images showing the orbital motion of the components of Phi Herculis over a time span of 430 days.

Larger scale images are available at:
http://www.usno.navy.mil/pao/press/PhiHer/